

Having thus defined the invention; it is claimed:

1) A system for cleansing the atmosphere, including volatile organic compounds contained therein, drawn into the engine compartment of a vehicle having an internal combustion engine comprising:

a) a heat wheel within the engine compartment of said vehicle having a side defining an entrance face surface and an opposite side defining an exit face surface;

b) said vehicle having a forward vehicular opening through which a stream of atmosphere flows when the vehicle operates, said vehicular opening in fluid communication with a majority of the surface area of said entrance face surface of said heat wheel;

c) a heat inlet duct having an entrance end in fluid communication with said vehicular opening and an exit end adjacent a portion of said entrance face surface of said heat wheel;

d) a heat outlet duct having an entry end adjacent a portion of said exit face surface of said heat wheel and an exiting end in fluid communication with the emissions treating system of said vehicle, said entry end of said heat outlet duct and said exit end of said heat inlet duct generally aligned to be in registry with one another;

e) a heat transfer mechanism in fluid communication with atmosphere flowing within said heat inlet duct for raising the temperature thereof to a set value;

f) a drive for rotating said heat wheel so that at any given time a first position dependent portion of said heat wheel is in fluid communication with a first portion of said atmosphere stream drawn through said vehicular opening whereby said first atmosphere portion passes through the

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first position dependent portion of said heat wheel and exhausts back to atmosphere while a second position dependent portion of said heat wheel is in fluid communication with a second portion of said atmosphere stream drawn through said vehicular opening into said heated inlet duct whereby said second atmosphere portion is heated by said heat transfer mechanism and exhausted to said heat outlet duct after passing through said second position dependent portion of said heat wheel; and,

10 g) said heat wheel having a plurality of channels extending from said entrance face of said heat wheel to said exit face surface thereof, each channel having surfaces coated with an adsorber selected from the group consisting of zeolite, active carbon, carbon molecular sieves, mesapore solids and micropore solids whereby said volatile organic compounds are adsorbed in said first position dependent portion of said wheel and desorbed in said second position dependent portion of said wheel.

20 2) The system of claim 1 wherein each channel is bounded by configured walls extending from said entrance face surface to said exit end face of said heat wheel, each wall of inner channels forming on opposite sides thereof portions of adjacent channels whereby a honeycomb channel pattern extends through said heat wheel.

25 3) The system of claim 2 wherein said adsorber is activated carbon having micropore porosity, a coating density greater than 0.5 g/in³ and a particle size less than about 25 microns whereby ozone as well as said volatile organic compounds are removed from said atmosphere at percentages higher than at least about 30 per cent and said

higher temperatures are in the range of approximately 150 to 300°C and said heat transfer mechanism using sensible exhaust gas heat to heat said atmosphere stream portion in said heat inlet duct to said higher temperatures.

- 5 4) The system of claim 3 where said activated carbon has a particle size less than about 5 microns and said adsorption efficiencies are approximately 50% or higher.
- 10 5) The system of claim 3 wherein said walls of said heat wheel channels are formed from material selected from the group consisting of metals, ceramics and plastics, said walls forming a substrate for receiving particles of said activated carbon.
- 15 6) The system of claim 5 wherein said activated carbon is bound to said substrate as a coating by a binder said binder substantially including silicone in any form including polymeric silicones, silica sols and silicates, said binder being sufficient to withstand said temperatures in said second position dependent portion of said heat wheel.
- 20 7) The system of claim 2 wherein the configuration of said second position dependent portion of said heat wheel, said exit end of said heat inlet duct and said entry end of said heat outlet duct is substantially defined as an arcuate segment extending between radial lines forming an included angle anywhere between 10 to 45°, and said radial lines between adjacent heat wheel segments are spaced from one another to define a radial gap between adjacent heat wheel segments.

8) The system of claim 7 wherein the configuration of said first position dependent portion of said heat wheel is substantially defined as at least one arcuate segment extending between radial lines forming an included angle anywhere between 315° to 350°.

9) The system of claim 8 wherein said exit end of said heat inlet duct confronts one face surface of said heat wheel while said vehicle opening confronts the opposite face surface of said heat wheel whereby said atmosphere flow through said heat wheel in said second position dependent portion is counter to the direction of said atmosphere flow through said heat wheel in said first position dependent portion.

10) The system of claim 7 wherein said drive includes a motor and a microprocessor having a programmed routine for actuating said motor to rotate said heat wheel in a predetermined manner.

11) The system of claim 10 wherein said heat wheel is physically formed as a cylinder comprising axially extending arcuate segments spanning an included angle substantially equal to said included angle of said exit end of said heat inlet duct and said entry end of said heat outlet duct and said programmed routine causes said motor to rotate said wheel at angular increments equal to said included angle of said arcuate segments.

12) The system of claim 11 wherein said programmed routine causes said drive to rotatably index said wheel at a set time period modeled from the time it takes to desorb a wheel

segment which has been substantially saturated with adsorbed volatile organic compounds.

13) The system of claim 11 further including a hydrocarbon sensor positioned adjacent an exit face surface of said heat wheel whereat said atmosphere exits said heat wheel, said routine effective to periodically sample the hydrocarbon readings of said sensor to determine a change in sensed hydrocarbon beyond a set limit whereat said microprocessor causes said heat wheel to index a segment.

10 14) The system of claim 13 wherein said sensor is a calorimetric sensor positioned in said exit heat duct and said routine causes said heat wheel to index when said sensor fails to detect the presence of hydrocarbons.

15 15) The system of claim 13 further including an alarm in the cabin of said vehicle, said routine effective to cause said alarm to actuate indicating a replacement of said wheel when said routine determines that said sensor readings do not substantially change over a set time period.

20 16) The system of claim 3 further including an ozone depleting catalyst at one end of said channels adjacent the side of said heat wheel whereat said atmosphere exits said heat wheel, said activated carbon deposited at the opposite end of said channels adjacent the side of said heat wheel whereat said atmosphere enters said heat wheel.

25 17) The system of claim 16 wherein said ozone depleting catalyst is MnO².

18) The system of claim 3 wherein said vehicle has an exhaust system in fluid communication with an exhaust manifold on said engine, said exhaust system having a catalytic converter for purifying emissions from exhaust gases emitted by said engine, said portion of said inlet heat duct in heat transfer relation to said exhaust gases including a gas-to-gas heat exchanger in fluid communication with said exhaust gases and positioned within said second inlet duct.

10 19) The system of claim 3 wherein said exiting end of said heat outlet duct is in fluid communication with an intake manifold of said engine whereby said engine treats said VOC emissions prior to discharging the treated VOC emissions to a catalytic exhaust gas purifying system.

15 20) The system of claim 3 wherein said vehicle has an exhaust system including a catalytic converter and said exiting end of said heat outlet duct is in fluid communication with said exhaust system upstream of said catalytic converter.

20 21) The system of claim 20 wherein said exiting end of said heat outlet duct is also in fluid communication with an intake manifold on said vehicle.

25 22) The system of claim 3 wherein said heat wheel is an annular cylinder, said heat wheel channels extend radially through said heat wheel, and said heat inlet duct is positioned to extend radially outside of and about said heat wheel while said heat outlet duct is positioned radially inside of said heat wheel or vice-versa.

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23) The system of claim 3 wherein said engine has an exhaust manifold and said heat inlet duct in heat transfer relationship with the sensible heat of said exhaust gases includes a portion of said heat inlet duct formed contiguous with a portion of said exhaust manifold whereby said atmosphere stream portion flowing in said heat outlet duct is heated by contact with said exhaust manifold.

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24) The system of claim 6 wherein said coating results from heating a slurry of activated carbon with a binder containing silicone in any form including polymeric silicones, silica sols and silicates at elevated temperatures sufficient to stabilize said coating at temperatures up to at least about 300°C.

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25) The system of claim 24 wherein said elevated temperature is at least about 300°C and said coating results from a silicone latex binder in said slurry heated to an initial temperature in the presence of an inert gas.

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26) The system of claim 25 wherein said inert gas is nitrogen and said initial temperature is less than said elevated temperature.

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27) A system for cleansing the atmosphere, including volatile organic compounds contained therein, drawn into the engine compartment of a vehicle having an internal combustion engine comprising:

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a) a rotatable heat wheel having channels extending therethrough from one side to an opposite side of said heat wheel, said channels having a coating of activated carbon on the surface thereof, said activated carbon having micropore

porosity, a coating density greater than 0.5 g/in³ and a mean particle size less than about 25 microns;

b) means for directing a stream of atmosphere at engine cabin ambient temperature through a first position dependent portion of said heat wheel on one side of said heat wheel;

c) means for directing a heated stream of atmosphere through a second position dependent portion of said heat wheel at temperatures within the range of approximately 150-300°C; and

d) means for rotating said heat wheel.

28) The system of claim 27 wherein said particle size is not greater than about 5 microns.

29) The system of claim 28 wherein said channels are formed of walls in a honeycomb pattern where opposite surfaces of any given wall form portions of adjacent channels, said walls of said heat wheel channels are formed from material selected from the group consisting of metals, ceramics and plastics, said walls forming a substrate for receiving particles of said activated carbon.

30) The system of claim 25 wherein said activated carbon is bound to said substrate by a binder, said binder substantially including silicone in any form, said binder being sufficient to withstand said temperatures in said second position dependent portion of said heat wheel.

31) The system of claim 30 wherein said means for directing a heated stream of atmosphere includes means for directing the sensible heat of said exhaust gases through a portion of

an atmosphere stream to heat said atmosphere stream portion to said temperature range of from 150 to 300°C.

32) The system of claim 31 further including a heat outlet duct on the opposite side of said heat wheel from the side

5 whereat said means for directing a heated stream of atmosphere enters said heat wheel, said heat outlet duct in fluid communication with an intake manifold of said engine and a hydrocarbon sensor in said heat outlet duct for sensing the presence of hydrocarbons in the atmosphere in 10 said heat outlet duct, said means for rotating said heat wheel including a microprocessor and a programmed routine effective to control the rotation of said heat wheel as a function of the hydrocarbons sensed by said sensor.

33) The system of claim 32 wherein said sensor is a

15 calorimetric sensor having an oxidizing catalyst deposited on a surface thereof over which said atmosphere passes, a non catalyzed reference surface over which said atmosphere also passes and a heater for heating both catalyzed and non catalyzed surfaces to determine the presence or absence of 20 hydrocarbons.

34) The system of claim 27 wherein said coating results from heating a slurry of activated carbon with a binder

25 containing silicone in any form including polymeric silicones, silica sols and silicates at elevated temperatures sufficient to stabilize said coating at temperatures up to at least about 300°C.

35) The system of claim 34 wherein said elevated temperature is at least about 300°C and said coating results

from a silicone latex binder in said slurry heated to an initial temperature in the presence of an inert gas.

36) The system of claim 35 wherein said inert gas is nitrogen and said initial temperature is less than said elevated temperature.

5 37) A system for cleansing the atmosphere of volatile organic compounds contained therein that is drawn into the engine compartment of a vehicle having an internal combustion engine comprising:

10 a) a rotatable heat wheel having channels extending therethrough from one side to an opposite side of said heat wheel, said channels coated with an adsorber selected from the group consisting of zeolites, cordierites, active carbons, carbon molecular sieves, mesapore solids and micropore solids;

15 b) means for directing a stream of atmosphere at engine cabin ambient temperature through a first position dependent portion of said heat wheel on one side of said heat wheel;

20 c) means for directing a heated stream of atmosphere through a second position dependent portion of said heat wheel;

25 d) means for directing the heated stream of atmosphere after passing through said heat wheel to an exhaust emission system of said engine, said directing means including a heat outlet duct;

 e) means for rotating said heat wheel, and

30 f) a sensor in said heat outlet duct for determining the presence of hydrocarbon in the heated atmosphere whereby the effectiveness of said heat wheel is determined.

38) The system of claim 37 wherein said sensor is a calorimetric sensor having an oxidizing catalyst deposited on a surface thereof over which said atmosphere passes, a non catalyzed reference surface over which said atmosphere also passes and a heater for heating both catalyzed and non catalyzed surfaces to determine the presence or absence of hydrocarbons.

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39) The system of claim 38 wherein said means for rotating said heat wheel includes a microprocessor and a programmed routine effective to control the rotation of said heat wheel as a function of the hydrocarbons sensed by said sensor.

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40) The system of claim 39 wherein said routine causes said drive means to rotate said wheel through a fixed, included angle when said sensor fails to detect the presence of hydrocarbons for a set time period.

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41) The system of claim 40 wherein said system includes a warning indicator in a cabin of said vehicle, said warning indicator actuated by said microprocessor, said routine determining the effectiveness of said adsorber to desorb said volatile organic compounds and actuating said warning indicator when the effectiveness of said adsorber drops below a preset level whereby the effectiveness of the system to remove volatile organic compounds is monitored.

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42) The system of claim 41 wherein said adsorber is activated carbon having micropore porosity, a coating density greater than 0.5 g/in³ for substrates selected from the group consisting of metals, ceramics and plastics and a

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particle size less than about 10 microns whereby ozone as well as said volatile organic compounds are removed from said atmosphere at conversion percentages higher than at least about 50 per cent whereby the effectiveness of the system to monitor the effectiveness of the system to remove volatile organic compounds and ozone is monitored through one sensor.

43) A method for cleansing the atmosphere by a vehicle powered by an internal combustion engine comprising the steps of:

- a) drawing a first stream of atmosphere into the engine compartment of a vehicle by means of a fan and/or the motion of the vehicle, said first atmosphere steam being at ambient engine cabin temperature;
- b) drawing a second stream of atmosphere either separately from said first stream or split from said first stream into said second stream by means of a fan and/or the motion of the vehicle;
- c) heating said second atmosphere stream by sensible heat from exhaust gases produced by said engine to temperatures in the range of approximately 150 to 300°C;
- d) providing a heat wheel having channels extending therethrough from one side of said heat wheel to the opposite side of said heat wheel; said channels having as a coating thereon activated carbon of a micropore porosity, said carbon having a density of at least 0.5 g/in³ and a mean particle size not greater than 25 microns;
- e) passing said first stream of atmosphere through channels occupying, at any given time, a first position dependent portion of said heat wheel to adsorb volatile organic compounds contained in said atmosphere;

f) passing said second stream of heated atmosphere through channels occupying, at any given time, a second position dependent portion of said heat wheel to desorb volatile organic compounds contained in said channels;

5 g) directing said second stream of heated atmosphere with volatile organic compounds desorbed from said wheel to the gaseous emission treating system of said vehicle; and,

10 h) rotating said wheel so that before the channels in said first position dependent portion of said heat wheel become saturated with volatile organic compounds they are rotated into a position whereat the channels become channels forming the second position dependent portion of said heat wheel while the desorbed channels formerly forming the second position dependent portion of said heat wheel are 15 rotated into a position whereat the channels become part of the channels forming said first position dependent portion of said heat wheel.

20 44) The method of claim 43 wherein said heat wheel is rotated as a function of the time it takes to desorb the volatile organic compounds in said second position dependent portion of said heat wheel.

45) The method of claim 44 wherein said heating of said second atmosphere stream occurs by passing said second stream over an exhaust manifold of said engine.

25 46) The method of claim 45 further including the step of sensing the hydrocarbons in said second atmosphere stream after said second atmosphere stream has passed through said second position dependent portion of said heat wheel and rotating said heat wheel through a set, included angle when

hydrocarbons are no longer sensed as being present for a set time period.

47) The method of claim 46 further including the step of providing an alarm in an operator cabin of said vehicle and actuating said alarm if hydrocarbons are not initially sensed upon rotation of said heat wheel.

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48) The method of claim 47 wherein said sensing step is accomplished by a calorimetric sensor having a heated catalyzed surface and a heated non-catalyzed surface over which a slip stream of said second atmosphere stream is passed after leaving said heat wheel.

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49) The method of claim 48 wherein the mean activated carbon particle size is less than 25 microns and said activated carbon including the step of reducing ozone in addition to adsorbing said volatile organic compounds so that the step of regenerating said activated carbon upon heating not only regenerating the ability of said activated carbon to adsorb volatile organic compounds but also regenerating the ability of said activated carbon to catalyze ozone reducing reactions to O².

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50) The method of claim 49 wherein the step of directing said second atmosphere stream to said vehicle's emission system after passing through said heat wheel occurs by initially directing said second atmosphere stream to an intake manifold of said engine.

51) The method of claim 50 wherein said wheel is divided into a plurality of arcuate segments of an included angle

extending between radial lines defining the edge of each segment, said wheel having a radial space between radial edge lines of each segment so that as each segment is rotated into said second position dependent portion, the
5 heat from the segment in said second position dependent portion tending to be isolated from the segments in said first position dependent portion.

10 52) The method of claim 51 wherein said rotation occurs by sensing the temperature of said exhaust gases and indexing said wheel before heat from said second position dependent portion of said wheel materially affects the temperature of said segments in said first dependent portion of said heat wheel provided that said hydrocarbons sensed in said heat outlet duct have dropped below a set value.

15 53) The method of claim 43 further including the step of adhering said activated carbon as a coating on said channels by providing a slurry of said activated carbon to which is added a silicone binder in any form and heating said slurry applied to said channels at elevated temperatures in the
20 presence of air to stabilize said coating at temperatures at least up to 300°C.

25 54) The method of claim 53 wherein said silicone binder is a silicone latex binder and said slurry is initially heated in only the presence of an inert gas at an initial temperature.

55) The method of claim 54 wherein said inert gas is nitrogen and said slurry is initially heated to temperatures

less than said elevated temperature and said elevated temperature is approximately 300°C.

56) A system for cleansing the atmosphere of volatile organic compounds contained therein that is drawn in to the engine compartment of a vehicle having an internal combustion engine comprising:

a) a rotatable heat wheel having portions containing channels through which an atmosphere stream and a heated atmosphere stream pass therethrough, said heat wheel having an adsorber composition coated on said channels;

b) a motor for rotating said wheel so that various portions of said wheel are sequentially heated by said heated atmosphere stream to desorb volatile organic compounds adsorbed from said atmosphere stream;

c) a sensor for sensing the presence of hydrocarbons in said heated atmosphere stream after passing through said wheel; and,

d) an alarm actuated by said sensor when said sensor detects that the wheel has aged to a condition whereat said wheel is not able to adsorb volatile organic compounds above a set limit.

57) The system of claim 56 wherein said sensor additionally determines actuation of said motor for rotating said wheel.

58) The system of claim 57 wherein said hydrocarbon sensor is a calorimetric sensor.

59) The system of claim 58 wherein said adsorber is activated carbon.